A GEOMETRY PROJECTION METHOD FOR SHAPE OPTIMIZATION WITH DESIGN-DEPENDENT BOUNDARY LOADS

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This paper presents a new fictitious domain method for solving shape optimization problems with design-dependent boundary loads. In previous work we introduced a fictitious domain method for shape optimization in which an analytical description of an embedded domain ω is the control from which the material projection measure is inferred. This contrasts with geometry models commonly used in topology optimization, where the material density measure is the control from which the geometry is inferred. Our approach provides an unambiguous geometry model from which all geometric properties and their sensitivities can be readily evaluated. In additon, it is often possible to represent ω with fewer design parameters than are required with raster representations of the material measure. As in all fictitious domain methods, meshing is simplified and there is no need for the mesh to track the boundary as the design evolves.

In this paper, we extend the method to address problems with design-dependent boundary loads. Since a precise description of the boundary is available, energy-consistent nodal loads can be easily computed for each element that intersects a design-dependent traction boundary. Surface normals and other surface quantities are readily available from the analytical geometry model, a distinct advantage relative to mesh-based, raster-style geometry models. Design sensitivities, too, are easily evaluated by the direct method. We present numerical examples that validate the convergence of the response analysis, as well as several optimization examples.